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INVESTIGATION OF RELATIONSHIPS
BETWEEN LINEARS, TONAL AND HAZY ANOMALIES,
AND PETROLEUM PRODUCTION IN THE
WILLISTON BASIN - AN ERTS - APPROACH

Semi-Annual Status Report
(November, 1974 To April, 1975)

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GRANT NSG 5018

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ABSTRACT

Study of Williston Basin linears and tonal features from ERTS-1 imagery is progressing according to the schedule proposed in Grant NSG 5018. Linear mapping on Band 5 and 7 imagery has been accomplished; tonal mapping is one-third finished. Examples of patterns to be expected from this work are included herein, but should be treated as preliminary drafts. No interpretation was desired or intended in this phase of the work.

"Hazy anomalies" as seen by us are either not equivalent to those reported by other workers, or, if equivalent, seem to have no reproducibility or consistency that would lead to a significant interpretation as being petroleum related. We believe further study should be made for technical or atmospheric causes of hazy "anomalies" in addition to the geologic studies now being made.

The interpretive phase of the Williston Basin study is now beginning. It will attempt to identify anomalies, to examine relationships between locations of known petroleum production and ERTS-derived data, and to note any correlations between the two which might serve as a tool for future petroleum exploration.

INTRODUCTION

Purpose. -- The status report which follows is designed to acquaint the reader with progress to date on grant NSG 5018. Purpose of this effort is to identify and map linear and tonal (including "Hazy") features from ERTS-1 imagery of the Williston Basin in North Dakota and northern South Dakota with the intent of relating these features to known areas of hydrocarbon production (if possible). As noted in our original proposal this work was to be conducted in three phases:

- 1) Define and map linears in the Williston Basin from ERTS and high altitude imagery (if needed);
- 2) Delineate Tonal Anomalies including Hazy Anomalies;
- 3) Interpret the significance of these patterns and their potential relationship to Williston Basin hydrocarbon production.

The work has proceeded according to the proposed program.

Methods. -- The area covered by imagery acquired through Goddard Spaceflight Center (GSFC) was divided into a northern and southern portion for mapping of linears. It had been intended that cloud free multi-seasonal coverage would be available for the entire study region, but such imagery was apparently not available, thus precluding detailed seasonal analysis of linears. Research Assistants O'Brien and Munsell have developed linear mosaics of the region for both Band 5 and Band 7 imagery using acetate-overlay mapping techniques. A variety of symbols were employed to record linear features, but these have not been developed into a rigorous system due to the high degree of subjectivity in such mapping.

Azimuths have been determined for straight (rectilinear) features on all Band 5 and Band 7 overlays. These have been grouped in 5-degree intervals. No

statistics have been applied to these measurements, nor is statistical treatment currently anticipated.

Tonal and Hazy qualities of imagery are being evaluated by Erickson and Street also using acetate-overlay mapping and mosaicing. All bands are being examined but mapping attempts have thus far been confined to Band 4 since this imagery has been thought to best demonstrate "Hazy Anomalies" (Eason Oil Report). As will be noted below interpretation of Hazy areas is considerably more subjective than interpretation of linears and it had been hoped that samples of Anadarko Basin Imagery on which hazy features were first noted would be available for comparison, but such was not the case.

Tonal mapping is approximately one-third complete at present. Final, accurate, mosaic maps of all types are in preparation. Maps accompanying this report should not be considered final.

PRELIMINARY FINDINGS

Linear Features. -- As used herein the term "linears" refers collectively to both rectilinear and curvilinear features. Rectilinears are those linears which are straight and thus provide measurable azimuths. Curvilinears are all other line-composed features; they may be closed (i.e., elliptical, circular, etc.) or open (arcuate) features. No linears of identifiable human origin were recorded.

Linear features mapped include abrupt tonal changes, straight segments of drainage, elongate lakes or sequences of lakes, aligned streams, truncated agricultural patterns for no visible reason and single lines of anomalous tone from that of the background. Reproducibility tests were conducted at the beginning of the study during which both O'Brien and Munsell mapped the

exact same image in the same Band. Subjectivity of linear identification was clear from the variation in results. They have developed standardized linear recognition for their own work, but it is unlikely that they would produce duplicate maps of each other's areas were they to switch. We doubt that any two workers would produce duplicate maps of an identical image.

The following points are compiled from summaries by Munsell and O'Brien:

- 1) Data obtained vary considerably from Band 5 and Band 7. Rectilinears are more apparent on Band 7, whereas curvilinears and "tonal" linears are more apparent on Band 5.
- 2) Rectilinears became obscure when they entered agricultural areas. If seen they appear as a very subtle change in tone of the fields.
- 3) Rectilinears are thus better developed in non-agricultural areas (open grazing, badlands, some flood plains), but some such areas show no features of any kind (=hazy?).
- 4) Some rectilinears are very well shown on imagery of snow-covered terrain; many are only seen under these conditions. It is assumed that such features have topographic expression and are enhanced by snow and perhaps by lower sun elevations as well.
- 5) Curvilinears were less often seen on snow-covered imagery; they appear to be more often tonal rather than topographic in origin.
- 6) Tonal linears were not consistent in position from one band to another, nor were they consistent on similar bands on the same centers, for the same or for different seasons.
- 7) Imagery quality varies greatly both in the original image and in the photographic printing of the image. Comparisons made with photos printed from 70mm negative imagery in our darkroom seem to indicate

considerable non-uniformity of processing of ERTS imagery.

- 8) Azimuth orientation measurements usually produce similar results for Bands 5 and 7 although different linears appear on each. Marked variation between bands usually occurs only when one band produces a poor-quality image.

Plate 1 is a preliminary draft of the linears map of Band 7 Summer imagery. No structural (geologic) intent is implied or attributed to it at this stage of the research. A Band 5 linears map has also been prepared but has not been included in this report. On Plate 1 both curvilinears and rectilinears are mapped and are purposely shown without differentiation. Later, interpretive maps will include separate displays and interpretations.

Simple azimuth groupings of rectilinears have been placed on Plate 2 according to the approximate image center upon which they were mapped. All figures are for Band 7 Summer imagery. As with Plate 1 no structural trends should be interpreted from these data. At this point we feel that the display is representative of rectilinear patterns within the Williston Basin, however.

Tonal and Hazy Features. -- Mapping of tonal features is incomplete as yet. Tonal differences are abundant on the available imagery. These tones are exceedingly variable from band to band. Their interpretation is seriously hindered by the seeming lack of consistency in the photographic printing process.

Plate 3 is a map of distributions of basic tonal styles of the Band 4 imagery. It largely distinguishes agricultural areas (CR) from other land use areas. Non-agricultural areas are shown as textured (Tx)

regions, usually being light gray monotone. Unusual or undistinguishable tonal patterns are shown with broken boundaries or are stippled.

At this stage of the research some preliminary comments upon "Hazy Anomalies" may be warranted. Numerous regions which appear "hazy" on Band 4 imagery are delineated on Plate 3. Most of these are tentative; they are termed "hazy" because no detail whatsoever, or nearly none, can be seen on the imagery. These hazy areas are not consistent from season to season, nor do they recur at the same location in the same season on imagery made one year apart. This would tend to indicate that they are not a function of the physical or chemical make up of the surficial deposits of the region. Rather it points strongly to atmospheric or to photographic or imaging processes as a cause.

In addition to random hazy areas, most of the prints we have obtained show a 6 to 8mm "faded" dark region all around the border, also interpreted as a photo reproduction problem. This area is totally unsatisfactory for tonal study and makes mosaic mapping of tones difficult, if not unreliable.

PHASE 3 - INTERPRETATION

With the exception of some tonal mapping, phases one and two of the study are complete. It is anticipated that a full set of derivative maps will be produced. At that point the interpretive phase of the study will begin along several pathways.

1) Attempts will be made to separate documented features from those which have not been recorded before. We may request high altitude imagery to aid in this work.

2) ~~Thus~~^A Areas of anomalous character will be defined.

3) Relationships of mapped features to location of known hydrocarbon production will be examined through detailed studies.

4) Correlations (if any) of defined anomalies with areas known production will be documented and described and their potential for future petroleum exploration will be noted.

PLATES 1, 2, AND 3 NOT FILMED